Instrumentation

Instruction Manual

for Model DM-03

Model 7100

AC-DC Converter Module

FAIRCHILD

INSTRUMENTATION

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Instruction Manual
for Model DM-03

Model 7100
AC-DC Converter Module

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EQUIPMENT WARRANTY

Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to repair, replacement with equivalent Fairchild equipment, or an appropriate credit adjustment not to exceed the original equipment sales price, of equipment returned to the Seller provided that:

a. Seller is promptly notified in writing by Buyer upon discovery of defects,

b. The defective equipment is returned to Seller, transportation charges prepaid by Buyer, and,

c. Seller's examination of such equipment discloses to its satisfaction that defects were not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the Buyer.

This warranty does not include mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age such as vacuum tubes, chopper, lamps, etc. In the case of accessories, i.e., card punches, typewriters, etc., not manufactured by the Seller, but which are furnished with the Seller's equipment, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

This warranty is applicable to the original Buyer only and constitutes the sole and exclusive warranty of Seller.

No other warranty is made, expressed or implied.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. The Fairchild Instrumentation DM-03 AC to DC Converter is a plug-in module designed for use with the Model 7100 Integrating Digital Meter. The unit measures AC voltages by converting unknown AC input levels to equivalent DC voltages which are measured by the Model 7100. The AC converter circuit produces readings which are proportional to the average value of the applied AC; and the readings are calibrated in rms, based on the assumption of a sine wave input. The AC to DC converter uses a solid-state high gain amplifier with AC and DC feedback to provide stability and accuracy. The DM-03 plugs into the opening on the front panel of the Model 7100 and provides four ranges of AC measurement (manual range selection only) with the following Model 7100 models:

Model No.	Readout Capability
7100/7101	Volts, ohms, ratio
7140/7141	Volts

1-3. Table 1-1 lists complete electrical specifications for the DM-03.

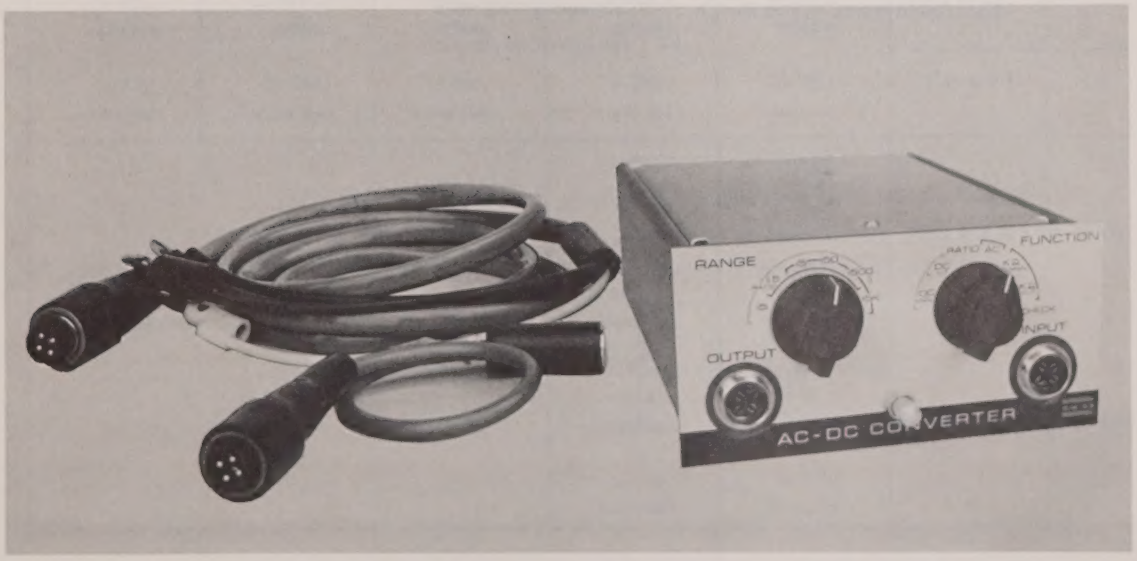

Figure 1-1. DM-03 AC to DC Converter

Table 1-1. DM-03 Electrical Specifications

AC Voltage Ranges: Four manually selected ranges of 1.0000, 10.000, 100.00 and 1000.0 V rms with 50% overrange on all ranges except 1000 V range.

Frequency Range: 30 Hz to 30 kHz

Input Impedance: 5 megohms ±1%, shunted by <50 pf.

Input Cable: Standard 5 feet length. Cable capacitance < 25 pf/ft.

Readout Accuracy: As detailed in table below:

Range	Input Level	Input Frequency				
		30 Hz - 10 kHz	10 kHz - 15 kHz	15 kHz - 20 kHz	20 kHz - 25 kHz	25 kHz - 30 kHz
1 V	0 to .1 V	±.03% of full scale	±.04% of full scale	±.05% of full scale	±.05% of full scale	±.05% of full scale
	.1 V to 1.5 V	±.05% of reading + .02% of full scale	±.06% of reading + .03% of full scale	±.1% of reading + .04% of full scale	±.15% of reading + .05% of full scale	±.2% of reading + .05% of full scale
10 V	1 V to 15 V					
100 V	10 V to 150 V	(A) ±.05% of reading + .02% of full scale	(A) ±.2% of reading + .03% of full scale	(B) ±.2% of reading + .05% of full scale	Note: Specification (A) is for standard DM-03; Specification (B) is for DM-03 with extended HF specifications.	
1000 V*	100 V to 500 V	(B) ±.1% of reading + .02% of full scale	(B) ±.12% of reading + .03% of full scale			

* For signals above 500 V rms, add ±0.0005%/V voltage coefficient.

Table 1-1. DM-03 Electrical Specifications (Cont.)

Temperature Coefficient:	35 Hz to 8 kHz
	±0.005% of reading + 0.002% of full scale per °C
	8 kHz to 15 kHz
	±0.01% of reading + .004% of full scale per °C
	15 kHz to 30 kHz
	±0.02% of reading + .01% of full scale per °C
	Maximum rate of change of ambient temperatures 10°C per hour
Reference, operating in extreme operating conditions per ASA C39.6.	
Humidity:	Maximum relative humidity not to exceed 75% in rated operating condition.
Power Requirements:	Self-contained power supply, 117 V 50 - 400 Hz 2 VA. For 220 V operation, correct power is automatically supplied by Model 7100.

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SECTION II
INSTALLATION

2-1. SCOPE OF SECTION

2-2. This section contains instructions for initial installation and inspection of the Model DM-03 AC to DC converter. In addition, reshipment instructions are provided in the event that the module must be returned to Fairchild Instrumentation.

2-3. UNPACKING

2-4. Before releasing the carrier, inspect the packed unit for any sign of external damage. If damage is noted, it should be called to the attention of the carrier and noted on the receiving receipt. Do not proceed with unpacking until instructed to do so by the authority of the insuring agency.

2-5. MECHANICAL INSPECTION

2-6. Inspect the front panel for damage to knobs and connectors. Note any scratches or dents. Rotate the front panel controls through their complete range and note any sticking, binding, etc. Examine the unit for damage to components, wiring, etc.

2-7. PERFORMANCE CHECK

2-8. The DM-03 is completely aligned, calibrated, and checked before shipment and is ready for use upon receipt. A quick check to ensure that the module is operating correctly and has suffered no damage in shipment may be made by carrying out the following steps:

a. Insert DM-03 into opening on front panel of serviceable Model 7100 and tighten retaining screw.

b. Connect short lead supplied with DM-03 between DM-03 OUTPUT jack and VOLT jack on front panel of Model 7100.

c. Set FUNCTION switch to AC and RANGE switch to 1500.

d. Connect DM-03 test cable to module and short HI (red), LO (black), and GUARD (white) terminals on cable together.

e. Set Model 7100 POWER switch to ON and check that readout indicates 0000. 0 V ±2 digits.

f. Connect HI (red) and LO (black) terminals to AC power source. Connect GUARD (white) terminal to LO. Check that readout indicates power source level.

g. A detailed alignment and checkout procedure is contained in section V of this manual.

2-9. RESHIPMENT

2-10. When an instrument is damaged in shipment, the insurance investigator can order it returned. The responsibility for repacking and reshipment is the insurance company's. Neither the customer or Fairchild are required to assume such responsibility without specific understanding with the insurance company through proper representatives.

2-11. When an undamaged unit is to be returned, an agreement will be made between Fairchild and the customer as to procedure.

SECTION III
OPERATION

3-1 SCOPE OF SECTION

3-2. This section contains a description of the DM-03 front panel controls and connectors, followed by instructions on how to use the module with the Model 7100. (See figure 3-1.)

3-3 CONTROLS

3-4. The purpose of the front panel controls and connectors on the DM-03 is defined as follows:

a. OUTPUT connector (and cable) connects DM-03 output to VOLTS jack on front panel of Model 7100.

b. INPUT connector (and test cable) connects DM-03 to AC voltage source. (This test cable may also be used for volts dc and ratio measurements, by setting FUNCTION switch to appropriate setting.)

c. FUNCTION and RANGE rotary switches select Model 7100 mode of operation and readout ranges. The functions and ranges available are described in table 3-1.

3-5 AC MEASUREMENT

3-6. To measure AC voltages, carry out following steps:

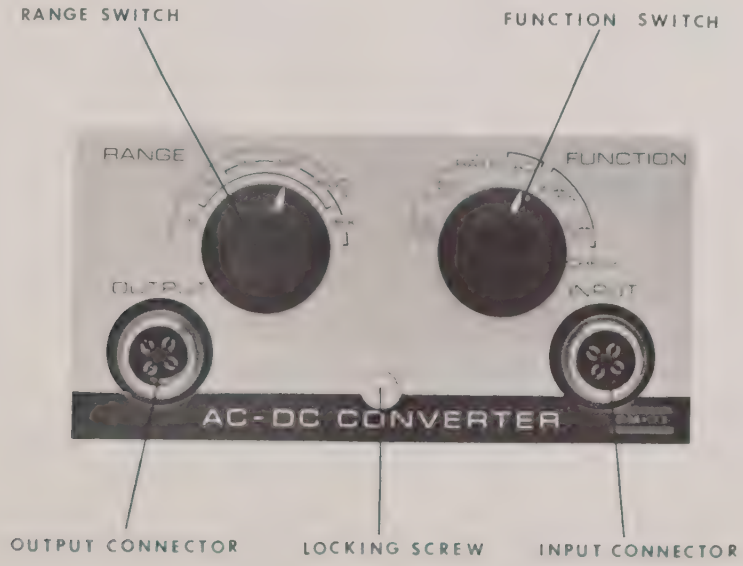


Figure 3-1 DM-03 Front Panel Controls

Table 3-1. FUNCTION/RANGE Control Settings

FUNCTION	RANGE						
	.15	1.5	15	150	1500	1.5 K	CHECK
DC MAN	±.10000 V + 50% overrange	±1.0000 V + 50% overrange	±10.000 V + 50% overrange	±100.00 V + 50% overrange	±1000.0 V	Not used	An instrument self-check function --- Readout is 10000 ±2 digits when Model 7100 is correctly aligned.
DC AUTO	±.10000 V + 50% overrange	±1.0000 V + 50% overrange	±10.000 V + 50% overrange	±100.00 V + 50% overrange	±1000.0 V	Not used	
RATIO	Not used	±1.0000:1 + 50% overrange	Not used	Not used	Not used	Not used	
AC	Not used	1.0000 V + 50% overrange	10.000 V + 50% overrange	100.00 V + 50% overrange	1000.0 V	Not used	
KΩ MAN	Not used	Not used	10.000 KΩ + 50% overrange	100.00 KΩ + 50% overrange	1000.0 KΩ + 50% overrange	15000 KΩ	
KΩ AUTO	Not used	Not used	10.000 KΩ + 50% overrange	100.00 KΩ + 50% overrange	1000.0 KΩ + 50% overrange	15000 KΩ	

3-5. AC MEASUREMENT

3-6. To measure AC voltages, carry out following steps:

a. Insert DM-03 into opening on front panel of Model 7100 and tighten retaining screw.

b. Connect short lead supplied with DM-03 between DM-03 OUTPUT jack and VOLTS jack on front panel of Model 7100.

c. Set FUNCTION switch to AC and RANGE switch to appropriate RANGE setting. Set POWER switch to ON.

d. Connect DM-03 test cable to AC signal source, observing instructions given in Model 7100 manual regarding use of LO (black), HI (red), and GUARD (white) terminals. Observe readout.

NOTE

1. On the 1.5 V range only, the maximum input should not exceed 200 volts. (The maximum input on all other ranges is 1000 V.) Signals in excess of this value will cause no physical damage, but, depending on the amplitude and frequency, may not operate the OVERLOAD indicator on the Model 7100.

2. To achieve the readout accuracy specifications quoted for the DM-03, the user must select the AC readout range that gives the greatest resolution of the voltage level under test. The correct ranges for inputs between 0 and 1000 volts are as follows:

Input Voltage	Range Setting
0 to 1.5 V	1.5
1.5 V to 15 V	15
15 V to 150 V	150
150 V to 1000 V	1500

3. Minute differences in stray capacitance in the range switching circuits will cause noticeable deviations at frequencies above 5 kHz. In order to ensure that the switch rotor always comes to a stop in the same position, the range switch should be rotated in a clockwise direction when changing range. The most critical range is 10 V.

SECTION IV
THEORY OF OPERATION

4-1. SCOPE OF SECTION

4-2. This section contains a description of the theory of operation of the Model DM-03 AC to DC Converter. The theory consists of a general description of operating principles followed by a detailed discussion of various sections of the plug-in. Reference should be made to figure 5-9 for a detailed schematic of the unit.

4-3. GENERAL DESCRIPTION

4-4. Measurement of AC voltages is performed by converting the unknown value of AC voltage to an equivalent DC voltage that can be measured on the Model 7100. A block diagram of the AC measurement circuit is shown in figure 4-1. The unknown AC voltage is coupled to an attenuator that attenuates the AC input by a factor of 1:1, 10:1, 100:1, and 1000:1. This restricts the input to the converter to a maximum of 1 volt rms for full scale inputs of 1 v, 10 v, 100 v and 1000 v, respectively. Potentiometers and trimmers in the circuit allow low and high frequency compensation adjustments to be made. The output of the attenuator is coupled via RANGE switch S1 and current limiting resistor A3-R2 to the input of a high gain wide-band amplifier. From the amplifier output, the signal is coupled to A1-CR1, A1-CR2, a full-wave rectifier and from there to A1-R3, A1-R4, A3-R22, and A3-R23, a set of current summing resistors. At the junction of A1-R3, A1-R4, and A3-R22, the AC

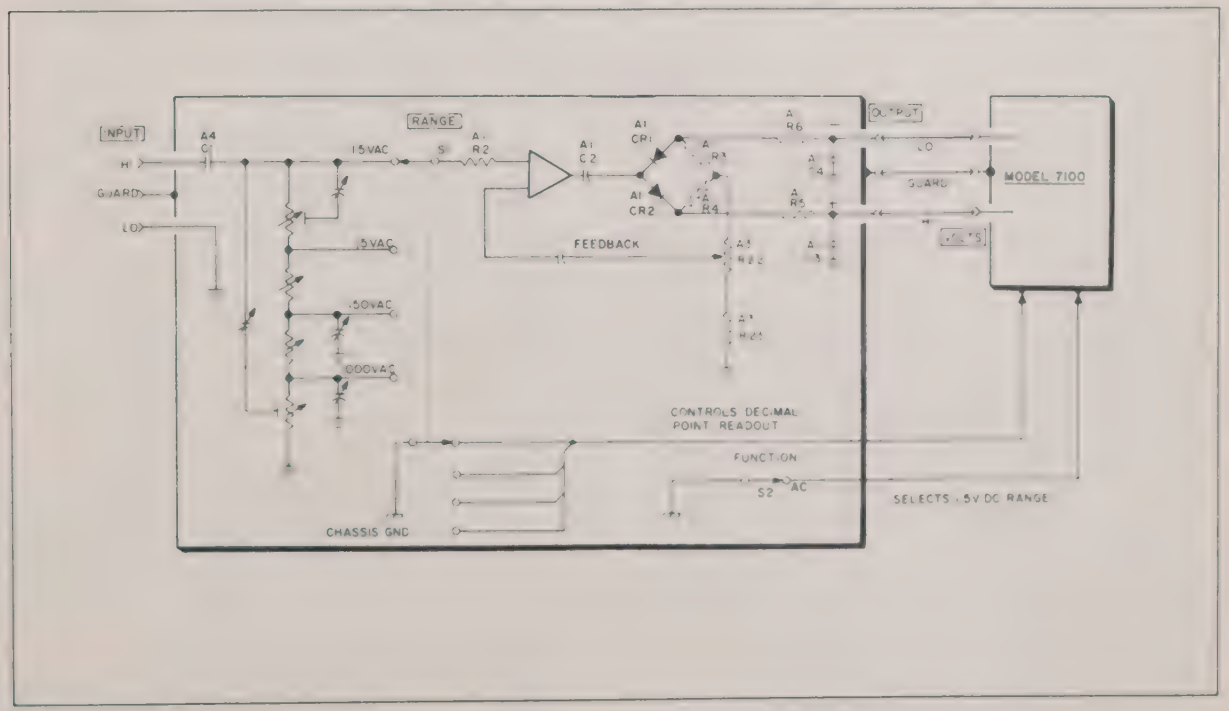


Figure 4-1. AC Measurement Block Diagram

signal is restored and feedback from this point is returned to the amplifier input. The rectified signals are fed through output filters A1-R6, A1-C4, and A1-R5, A1-C3, to the OUTPUT connector on the DM-03 and the VOLTS input on the Model 7100. The amplifier gain and feedback circuits are calibrated so that the rectified DC output is equivalent to the true rms value of a pure sine wave at the amplifier output. The DC readout mode on the Model 7100 is preset to the 1.5 volt DC range by the AC position on the FUNCTION switch. This causes the DC readout on all AC ranges to be at some level between zero and 1 volt, plus a 50% overrange. The decimal point position is selected by the RANGE switch, according to the input attenuator setting, so that the readout indicates the actual AC voltage applied to the instrument.

4-5. The AC to DC conversion circuit described above is an average responding type that measures the average rectified value of a sine wave input. (Average value is 0.636 times peak value.) The instrument, however, is calibrated in such a manner that the root-mean-square (rms) value of a pure sine wave is indicated. (rms value is 0.707 times peak value.) Calibration of an average responding system to the true rms value by manipulation of the calibration adjustments is permissible and will produce valid readings as long as the input signal is a pure sine wave or has only a negligible amount of distortion. The extent to which the readout accuracy is affected by distortion is shown in table 4-1. It should be noted that the percentages given are maximum values, the actual error can be positive or negative and much less, depending upon the phase relationship between the fundamental and harmonics of the input signal.

Table 4-1. Measurement Errors From Harmonic Voltages

Harmonic Content in Waveform	Maximum Error Expected
2%, 2nd	0.02%
4%	0.08%
6%	0.18%
8%	0.32%
10%	0.5%
20%	2%
50%, 2nd	12%
.3%, 3rd	0.1%
.5%	0.17%
1%	0.35%
5%	1.7%
10%	4.5%
20%	8%
50%, 3rd	22%

4-6. ATTENUATOR

4-7. Figure 4-2 is a basic diagram of the DM-03 input attenuator. In the AC mode of operation, the AC input signal is coupled through FUNCTION switch S1 and capacitor A4-C1 to RANGE switch S2 and the input of a 5 MΩ attenuator string. The string consists of fixed resistors A1-R1, A2-R2, A2-R4, and A2-R6, and potentiometers A2-R1, A2-R3, and A2-R5, all connected in series to give accurate attenuations of 20, 40, and 60 db. As the attenuator is always connected in the circuit, and the input impedance of the amplifier is extremely high, the effective input impedance of the converter is that of the attenuator string, i.e. 5 MΩ, shunted by some stray capacitance. A detailed description of attenuator operation for each of the AC range settings is given below:

1.5 VAC - The input signal is coupled directly through A4-C1 and A1-R2, a 330 kΩ, 2 w current limiting resistor to the input of the AC amplifier.

15 VAC - The input signal is attenuated by 20 db and potentiometer A2-R1 is the calibration adjustment for the low frequency band. A1-C1 is a trimmer capacitor located under the 4.95 MΩ resistor (R1) on board A1. This control is used for calibration of the 10 v range high frequency band. It should be noted that adjustment of A1-C1 will have no effect on the calibration of the 1 v range. It will, however, effect the 100 v and 1000 v ranges.

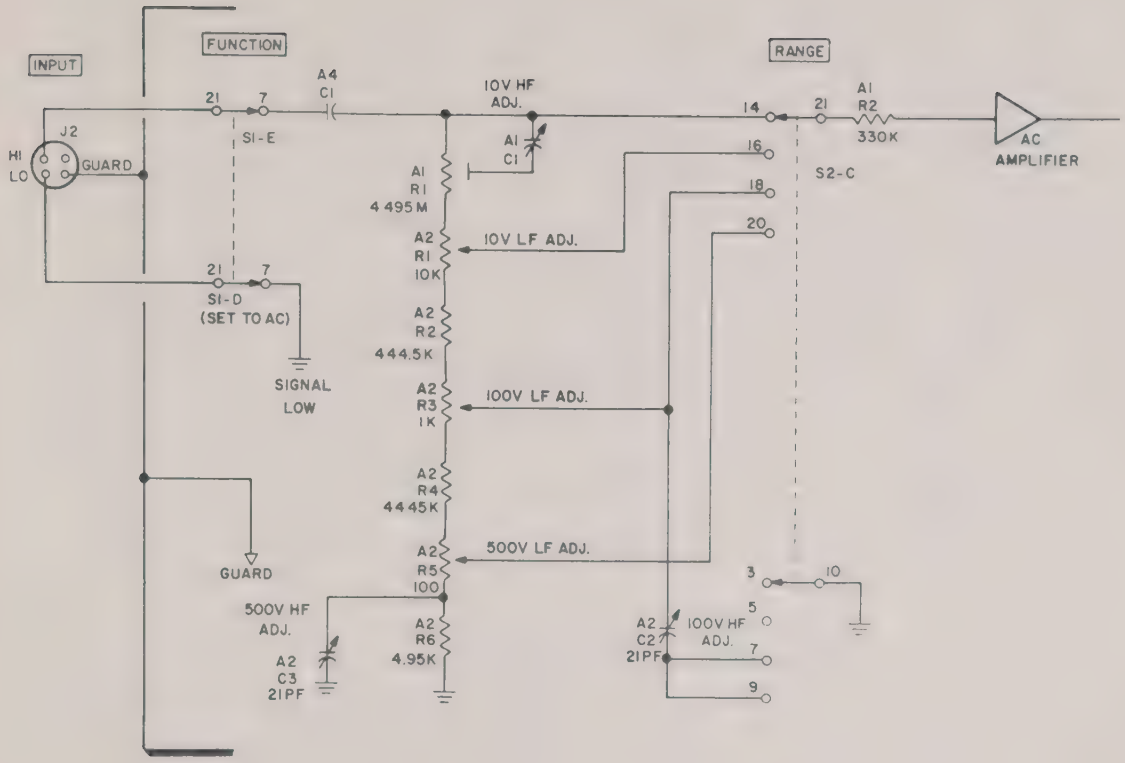


Figure 4-2. Input Attenuator

150 VAC - The input signal is attenuated by 40 db and potentiometer A2-R3 permits calibration of the LF band. In this range, the RANGE switch terminates capacitors A2-C1 and A2-C2 to signal low. A2-C2 is a trimmer capacitor used for calibration of the HF band. It should be noted that adjustment of A2-C2 will have no effect on the 1 v and 10 v calibration, but will affect the 1000 v range.

1000 VAC - The input signal is attenuated by 60 db. Potentiometer A2-R5 permits calibration of the LF band. Capacitor A2-C3 is a trimmer capacitor used for HF calibration on this range.

4-8. From the description of the attenuator given above, it is obvious that there is a certain amount of interaction between the various high frequency adjustments. This makes it imperative that the calibration procedure detailed in section V of this manual be carried out in the sequence given.

4-9. AC AMPLIFIER, DETECTOR, AND FILTER

4-10. Figure 4-3 is a simplified schematic of the AC amplifier, detector, and filter sections of the AC to DC converter circuit. The amplifier input signal (output of input attenuator) is fed to the base of transistor A3-Q2. The input stage consists of A3-Q2 and A3-Q4, a differential pair, with A3-Q3 supplying constant current. Diode A3-CR1 is a 2N708 transistor selected for a BV of 6 volts, and used as a zener. Zener diode A3-CR2, also a 2N708 with a BV of 6 volts, provides a regulated collector supply for A3-Q4. Transistors A3-Q2 and A3-Q1 are a cascaded amplifier pair. The signal at the collector of A3-Q1 is fed to the input of emitter follower A3-Q5

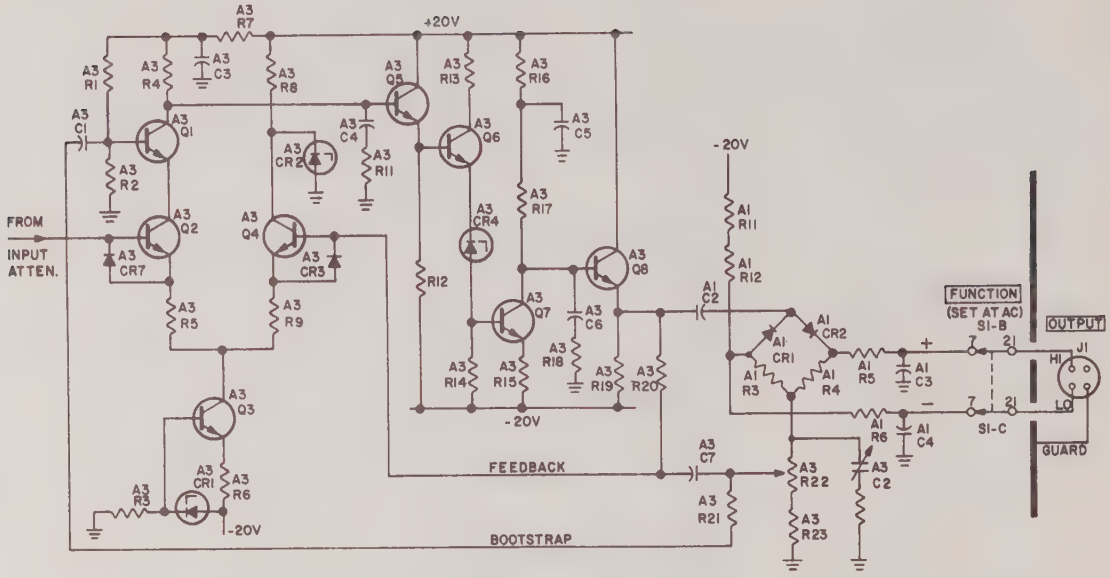


Figure 4–3. AC Amplifier, Detector, and Filter

and from the output of A3-Q5 to the input of emitter follower A3-Q6. At the base of A3-Q5, a rolloff network consisting of A3-C4 and A3-R11 is connected to circuit common. From the output of A3-Q6, the signal is DC coupled through 30 v zener A3-CR4 to the base of amplifier stage A3-Q7. From the output of A3-Q7, the signal is fed to the input of emitter follower A3-Q8 and its output is AC coupled by A1-C2 into output rectifiers A1-CR1 and A1-CR2.

4-11. From the anode of A1-CR1 and the cathode of A1-CR2, the two rectified half-waves are recombined through A1-R3 and A1-R4 into current summing resistors A3-R22 and A3ΩR23. Potentiometer A3-R22 is a gain adjustment and from there, the signal is fed back through capacitor A3-C7 to the base of A3-Q4 and also through A3-R21 and A3-C1 to the base of A3-Q1. The latter connection is a bootstrap circuit used to reduce the effects of the collector shunt capacitance of the input transistor. Resistor A3-R20 is used for DC feedback to ensure stable operating conditions. Due to the feedback and bootstrap circuits, the effective input impedance of the amplifier is extremely high and thus causes a minimum of attenuator loading.

4-12. The rectified positive half-cycle is connected from the cathode of A1-CR2 into an output filter consisting of A1-R5 and A1-C3 and from there to the signal high terminal on front panel OUTPUT connector J1. The negative half-cycle is connected from the anode of A1-CR1 into output filter A1-R6, A1-C4 and from there to the signal low terminal on the OUTPUT connector. It should be noted that the negative output (signal low) is not at the same potential as the AC converter common or signal low input. During the AC mode of operation, the Model 7100 circuit common is connected to the filtered negative output of the DM-03 and is therefore not common with the input cable signal low terminal.

4-13. POWER SUPPLY

4-14. A power supply mounted on board A1 provides regulated outputs of +20 volts and -20 volts for operation of the converter circuitry. Figure 4-4 is a basic

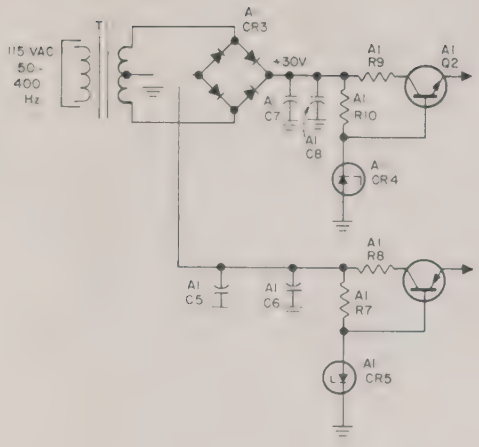


Figure 4-4. Power Supply

schematic of the supply. The circuit consists of A1-Q1 and A1-Q2, two series regulators powered by approximately -30 volts and +30 volts DC obtained from a rectifier circuit consisting of transformer T1, bridge rectifier assembly A1-CR3, and filter capacitors A1-C5, A1-C6, A1-C7 and A1-C8. Zener diode A1-CR4 establishes a base reference voltage of approximately +20 volts for A1-Q2. A1-Q2 absorbs voltage variations by operating as an emitter follower with the voltage at the emitter (supply output) maintained at a level slightly below the base reference level set by the diode. The current capability of the supply is approximately 10 milliamperes. The -20 volt output is derived from a similar circuit made up of PNP transistor A1-Q1 and diodes A1-CR6, A1-CR7.

4-15. FUNCTION/RANGE SWITCHING

4-16. FUNCTION switch S1 and RANGE switch S2 mounted on the front panel of the DM-03 select a) the AC measurement mode, with its four readout ranges and b) the modes of operation and ranges incorporated in the Model 7100 used with the DM-03. A basic schematic of the switching circuit is illustrated in figure 4-5 with S1 and S2 set for AC readout on the 1.5 volt range. During AC operation, the five sections of the FUNCTION switch operate as follows: S1-E and S1-D connect the leads from the DM-03 front panel INPUT connector to the input of the AC to DC converter; S1-C and S1-B connect the output of the converter to the DM-03 front panel OUTPUT connector; and S1-A grounds the "AC function" line connected to the Model 7100 mode/range programing logic. For all AC ranges, the Model 7100 is operated on the 1.5 volt DC range, with the integrator clock operated at 120 kHz rather than the normal 600 kHz rate. This necessitates operation of the relays in range assembly A16, not as shown in table 4-1 of the Model 7100 manual, but as follows:

K1	open	K10	open
K2	closed	K11	open
K3	open	K12	closed
K4	open	K13	open
K5	open	K14	open
K6	closed	K15	open
K7	open	K16	open
K8	closed	K17	closed
K9	open		

To achieve this, the relay programing matrix on board A11 in the Model 7100 is bypassed and the "AC function" ground is connected to pin 8 on terminal board A1 (figure 4-12, Model 7100 manual). This pulls in relays K2, K6, K8 and K12. The remainder of the relays, in their quiescent state, are in the desired condition. The "AC function" ground is also coupled to pin 2 on the polarity readout housing. This turns on the AC indicator in the readout display.

4-17. During AC operation section S2-C of the RANGE switch connects the AC amplifier input to the appropriate AC attenuator output and switches high frequency compensation components in the attenuator; section S2-A controls the decimal point readout on the Model 7100. (The normal decimal point drive circuit on board A11 is inoperative when the instrument is held in the 1.5 V DC range by the method previously described. Instead, the four deciman point

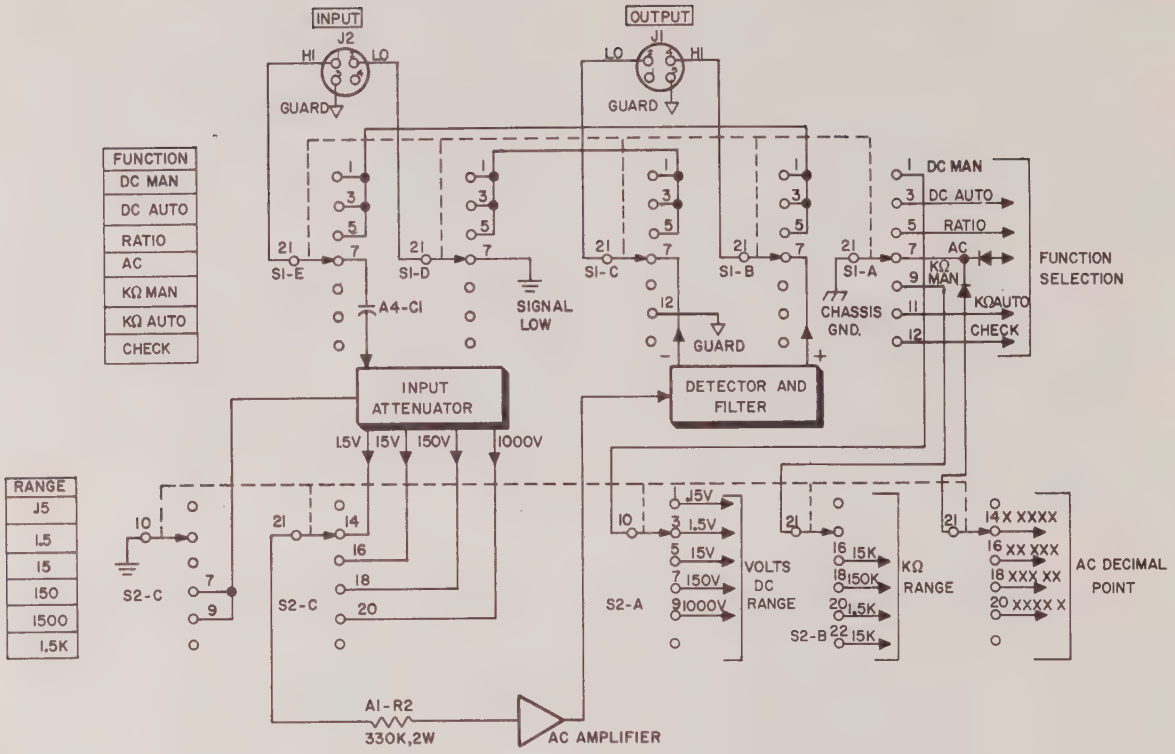


Figure 4-5. Function/Range Switching

lines from S2-A are connected directly to four decimal point neons and they are lit, according to the AC range selected, by providing a path to ground for the energising voltage.)

4-18. For measurement modes performed solely by the Model 7100, the FUNCTION and RANGE switches a) connect the DM-03 INPUT connector directly to the DM-03 OUTPUT connector and b) operate the Model 7100 programing relays in the same manner as the combined FUNCTION/RANGE switch fitted on the DM-01A and DM-02 plug-ins.

SECTION V
MAINTAINANCE

5-1. SCOPE OF SECTION

5-2. This section describes the equipment and methods used to calibrate the DM-03 and verify its performance in accordance with the specifications given for the module.

CAUTION

DO NOT ATTEMPT TO CLEAN THE PRINTED CIRCUIT BOARDS WITH ANY TYPE OF SOLVENT. IF IT IS NECESSARY TO HANDLE THE BOARDS, WEAR NYLON GLOVES.

5-3. TEST EQUIPMENT REQUIRED

5-4. Table 5-1 lists the test equipment required for all tests described in this section and figure 5-1 is a block diagram showing how the equipment is interconnected. It should be noted that the accuracy specifications quoted for the DM-03 are within an order of magnitude of the best AC measurement techniques known at this time and thus, during calibration and checkout, the quality of test equipment used, and the assessment of its accuracy, is very significant.

5-5. TEST RESULT INTERPRETATION

5-6. In the test set-up shown in figure 5-1, neglect-

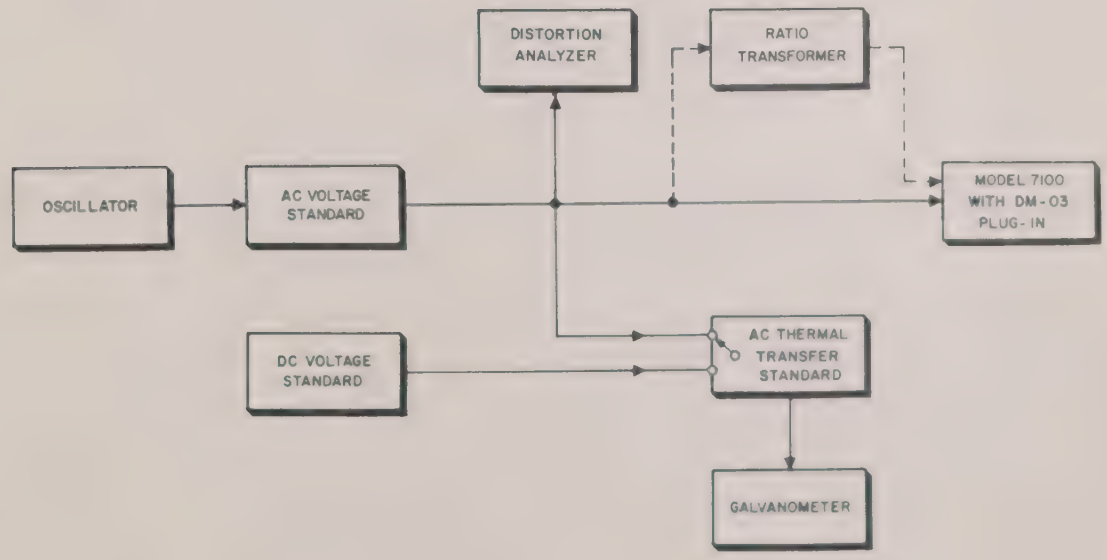


Figure 5-1. Test Set Up

Table 5-1. Test Equipment Required

Instrument Type	Purpose	Critical Specifications	Recommended
Oscillator	Provide low distortion sine wave signals	Freq. Range: 30 Hz to 30 kHz Harmonic Distortion: .05% max.	Holt Model 448 or Optimation Inc. Model AC-104A
Stable AC Voltage Source	Provide wide range of AC test voltages	Stability: ±0.02% Distortion: <.05% Output: Adjustable to 1000 V	Holt Model 323C or Optimation Inc. Model AC-104A
Ratio Transformer	Provide low-level AC voltages for linearity tests	Accuracy: .01% to 20 kHz	Gertsch Model RT-13 or Optimation Inc. Model AC-104A
DC Voltage Standard	Provide DC voltages for comparison in thermal transfer	Accuracy: .005%	Kintel Model 303 or Fluke Model 332A
AC Thermal Transfer Standard	Compare rms value of sine wave voltages from AC voltage source with DC output from DC voltage standard	Voltage Range: .25 to 1000 volts Frequency: 5 Hz to 50 kHz AC-DC Difference: ±0.01%	Holt Model 6A or Fluke Model 540B
Distortion Analyser	Analyse percentage of distortion in sine wave		Hewlett Packard Model 331A
Galvanometer	Determine balance in thermal transfer standard		Leeds-Northrup Model 24-30C

ing the effects of harmonic distortion from the oscillator and considering the AC voltage standard solely as a stable source of AC voltage, the accuracy of the input signal to the DM-03 is the sum of the accuracies of the DC voltage standard and the AC thermal transfer standard. With good equipment, a maximum error of 0.02% can be obtained. However, adding errors as the square root of the sum of their squares (a commonly used method of error analysis of randomly occuring peak errors in the measurement equipment) gives an rms error of approximately 0.015%.

5-7. If absolute accuracy is desired, the peak error values must be used, and the effects of the harmonic distortion content of the AC voltages being measured must be added to these values. Analysis of the effect of harmonic distortion on the average-reading type of circuitry used in the DM-03 indicates that the maximum error caused by harmonic distortion can reach 1/3 of the percentage of total harmonic distortion. Therefore, when an average-reading AC to DC converter is calibrated to give rms readout, (as in the case of the DM-03), a total harmonic distortion of 0.1% can cause a variation as great as 0.03% between the average and rms values of the sine wave being measured. However, an unusual phase relationship is required for the maximum error due to harmonic distortion to reach these values -- an error equal to 1/5 of the percentage of total harmonic distortion is a reasonable assumption. Thus, with a 0.1% maximum harmonic distortion of the AC signal source, an error of 0.02% may be assumed. The maximum total error at the input to the DM-03 can be calculated as follows:

	Error
DC Standard Accuracy	.01% (assumed)
AC Thermal Transfer Accuracy	.01% (assumed)
Total Harmonic Distortion 0.1%	.03% (worst case)
Total	.05%

Employing the same accuracy figures, but using the more reasonable .02% harmonic distortion error, the rms error summation method gives a total input error of:

$$(.01)^2 + (.01)^2 + (.02)^2$$

$$= .0245\%$$

As these errors are an appreciable part of the total error ascribed to the DM-03, the correct use of high quality test equipment is an obvious requirement.

5-8. CALIBRATION PROCEDURE

NOTE

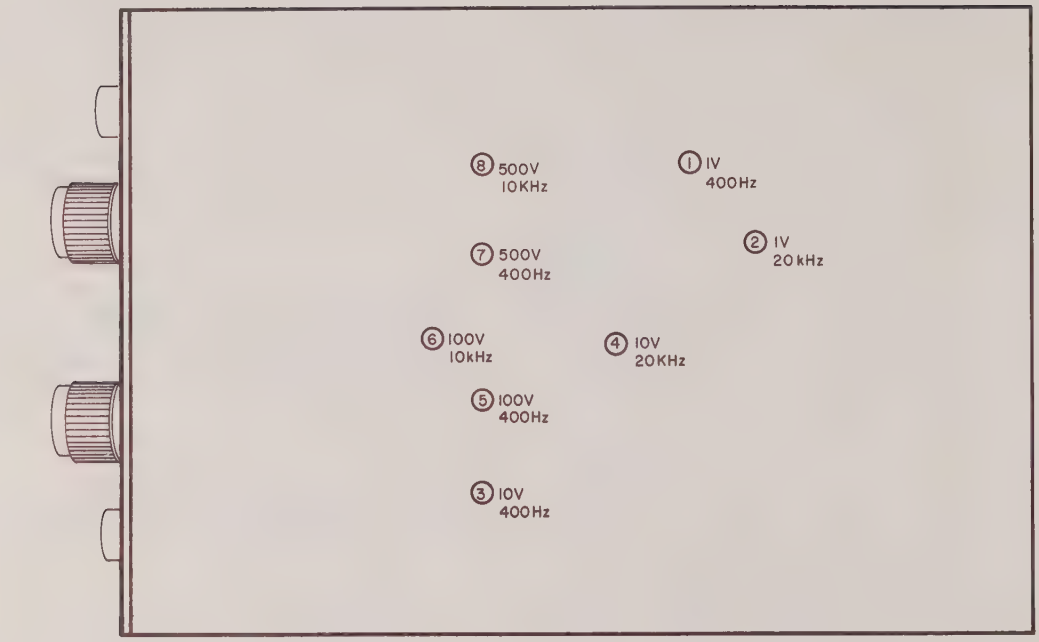
The calibration points as identified on the bottom cover of the instrument are for optimized performance from 30 Hz to 10 kHz. For extended frequency response follow the detailed steps 1 through 13 given in table 5-2.

5-9. To align and check out the DM-03, proceed as follows:

a. Insert DM-03 into a correctly aligned Model 7100 and connect OUTPUT cable on DM-03 to VOLTS input on Model 7100.

b. Place Model 7100 on its side and remove bottom cover plate. This exposes the DM-03 alignment controls, accessible through holes on the bottom cover of the module. See figure 5-2 for identification of these controls. Figure 5-2 also shows the location of the controls in a block diagram of the DM-03.

c. Connect the test equipment as shown in figure 5-1. Observe the proper use of HI, LO, and GUARD terminals. Set AC power to on and allow a 1/2 hour warmup period.



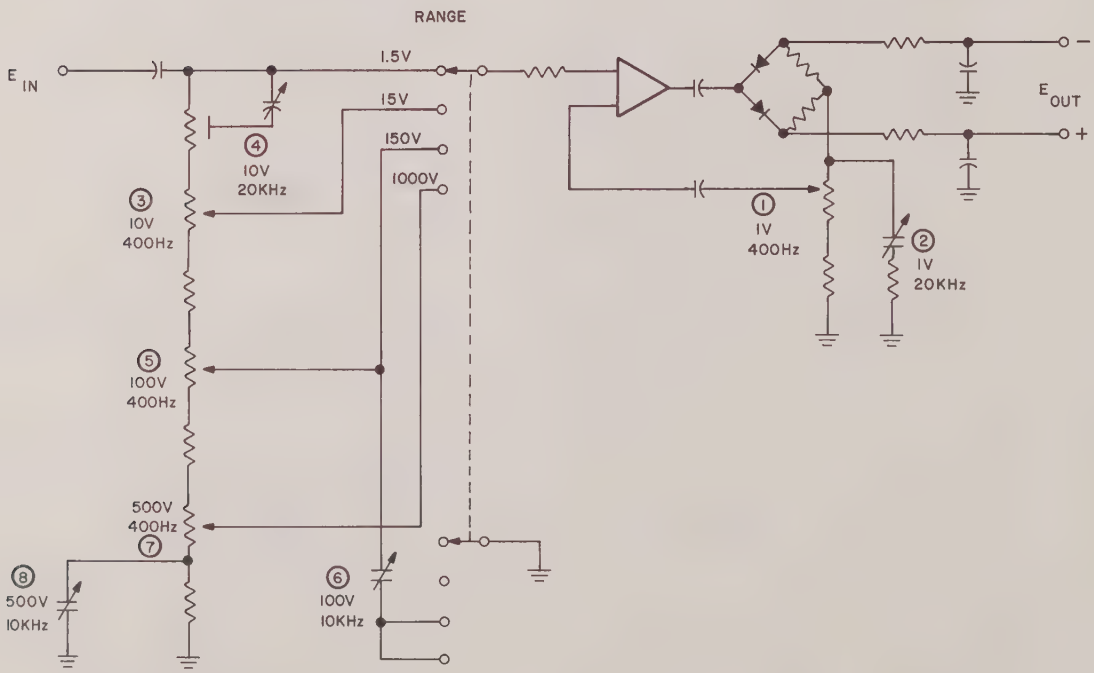


Figure 5-2. DM-03 Calibration Adjustments

Table 5-2. Calibration Adjustment and Checkout

Step	Range	Input Signal		Adjustment	Readout	Tolerance	Remarks
		Amplitude	Frequency				
1	1 V	1.0000 V	400 Hz 20 kHz	1 V 400 Hz 1 V 20 kHz	1.0000 V 1.0000 V	±1 digit	1 V Range cal. adj.
2	1 V	1.0000 V	35 Hz 5 kHz 10 kHz 15 kHz 20 kHz 30 kHz	-	1.0000 V	±7 digits ±7 digits ±7 digits ±9 digits ±14 digits ±25 digits	1 V Range cal. check
3	10 V	10.000 V	400 Hz 20 kHz	10 V 400 Hz 10 V 20 kHz	10.000 V 10.000 V	±1 digit	10 V Range cal. adj.
4	10 V	10.000 V	35 Hz 5 kHz 10 kHz 15 kHz 20 kHz 30 kHz	-	10.000 V	±7 digits ±7 digits ±7 digits ±9 digits ±14 digits ±25 digits	10 V Range cal. check
5	100 V	100.00 V	400 Hz 10 kHz	100 V 400 Hz 100 V 10 kHz	100.00 V 100.00 V	±1 digit	100 V and 1000 V Range cal., adj.
6	1000 V	500.00 V	400 Hz 10 kHz	500 V 400 Hz 500 V 10 kHz	0500.0 V 0500.0 V	±1 digit	
7	100 V	100.00 V	10 kHz	100 V 40 Hz	100.00 V	±1 digit	
8	1000 V	500.00 V	10 kHz	500 V 10 kHz	0500.0 V	±1 digit	
9	100 V	100.00 V	10 kHz	100 V 10 kHz	100.00 V	±1 digit	
10	100 V	100.00 V	35 Hz 5 kHz 10 kHz 15 kHz	-	100.00 V	±7 digits ±7 digits ±7 digits ±23 digits	100 V Range cal. check
11	1000 V	500.00 V	10 kHz	500 V 10 kHz	0500.0 V	±1 digit	1000 V Range cal. adj.
12	1000 V	500.00 V	35 Hz 5 kHz 10 kHz 15 kHz	-	0500.0 V	±5 digits ±5 digits ±5 digits ±13 digits	100 V Range cal. check
13	100 V	100.00 V	10 kHz 15 kHz		100.00 V	±7 digits ±23 digits	100 V Range cal. check

NOTE

Use a non-metallic alignment tool for all adjustments. Recommended is JFD Corporation adjustment tool No. 5284.

d. Set DM-03 front panel controls as follows:

FUNCTION	AC
RANGE	1.5

NOTE

Alignment frequencies and DVM readings given in table 5-2 are optimized for characteristic peaking and roll off of the DM-03. This alignment procedure will produce optimum flatness of frequency response.

e. Apply a 1.0000 V, 400 Hz signal to DM-03 input. Adjust 1 V 400 Hz control for Model 7100 readout of 1.0000 V ±1 digit.

f. Change input to 1.000 V, 20 kHz. Adjust 1 V 20 kHz for readout of 1.0000 V ±1 digit.

g. Consult table 5-2, step 2, and check readout for 1.0000 V input at six frequencies given. Note that in each case readout is within given tolerance. This completes the alignment and checkout of the 1 volt range.

h. Carry out steps 3 through 13 in table 5-2. This completes alignment and checkout of remaining three ranges.

5-10. STRAY CAPACITANCE

5-11. Figure 5-3 is a simplified schematic of a portion of the input attenuator (10 v range) that will help to illustrate the effect of stray capacitance. R1

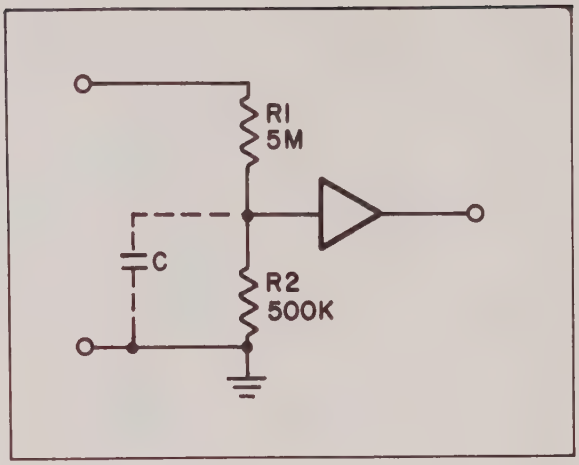


Figure 5-3. Stray Capacitance

and R2 are attenuator resistors and C represents some stray capacitance of wiring and components adjacent to other circuitry. C is a shunt impedance in parallel with R2. Since R2 is 500 kΩ, a shunt impedance of 500 MΩ will cause a shift in calibration accuracy of 0.1%. (The capacitive reactance of a .01 pf capacitor at 30 kHz is 500 MΩ). Obviously, it is physically impossible to design equipment that has no stray capacitance. Also, the actual conditions in the attenuator are more involved than shown in figure 5-2. To stabilize the effect of stray capacitance, the DM-03 is designed and packaged in such a manner that all critical components and wiring are in a fixed position. Altering the location of components, changing or moving wiring, or subjecting the instrument to unreasonably rough treatment will change this arrangement and affect the HF calibration.

5-14. COMPONENT LOCATION, OPERATING WAVEFORMS AND SCHEMATIC

5-13. Figure 5-4 through 5-7 are photographs showing the location of assemblies and components in the DM-03; figure 5-8 shows a number of typical operating waveforms; and figure 5-9 is a detailed schematic of the unit.

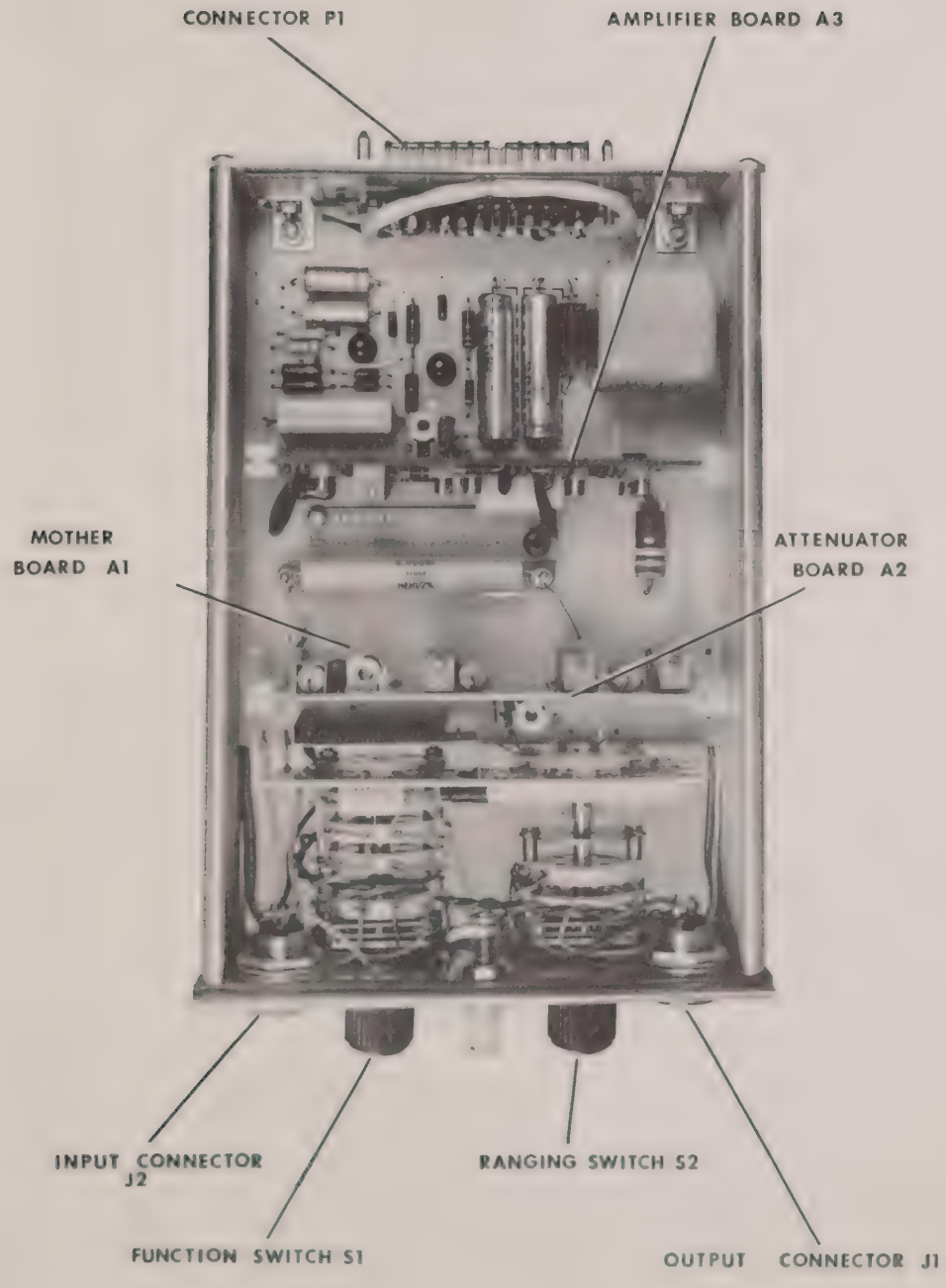


Figure 5-4. Assembly Location

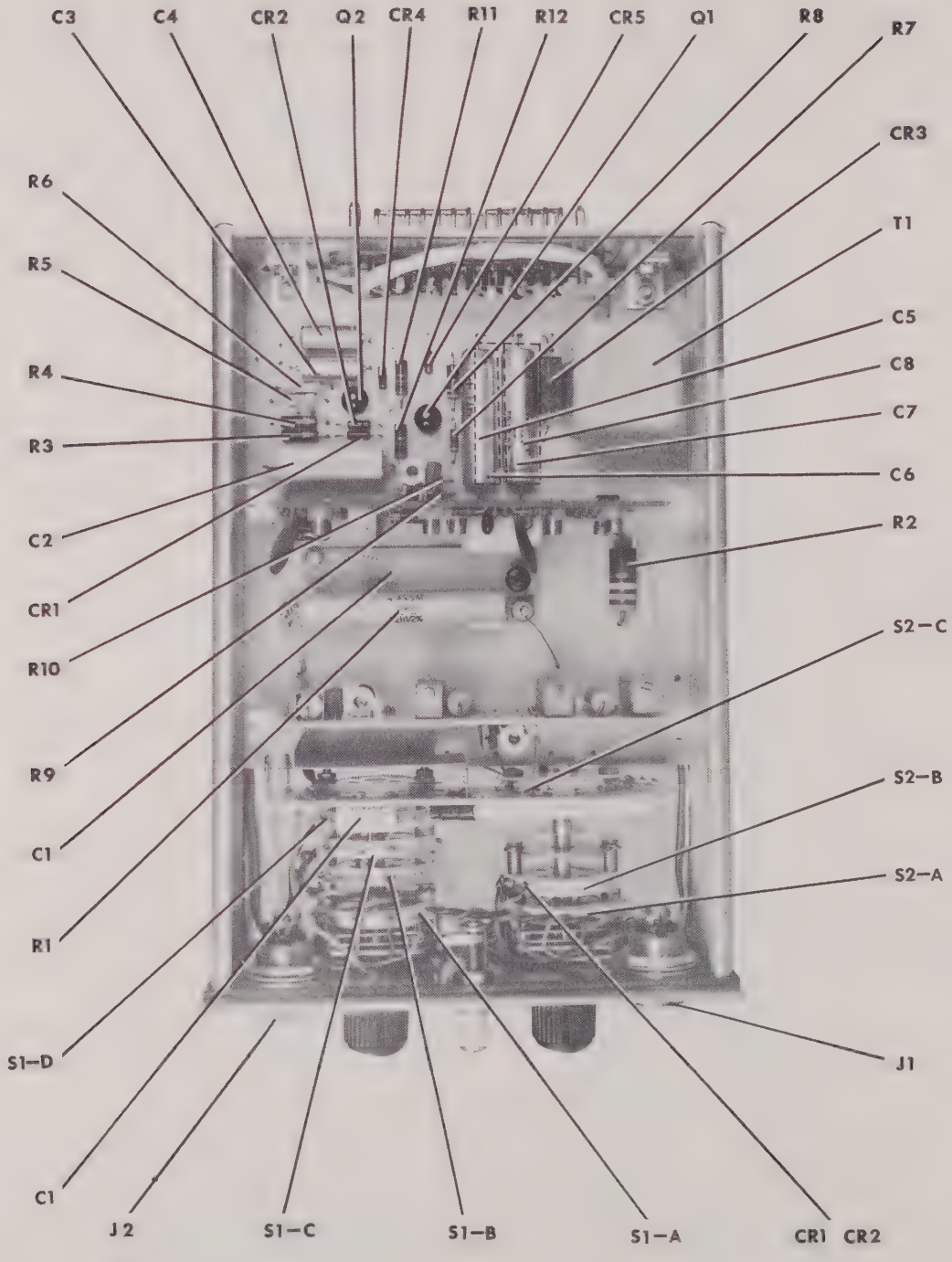


Figure 5-5. Frame Assembly and Board A1 Parts Location

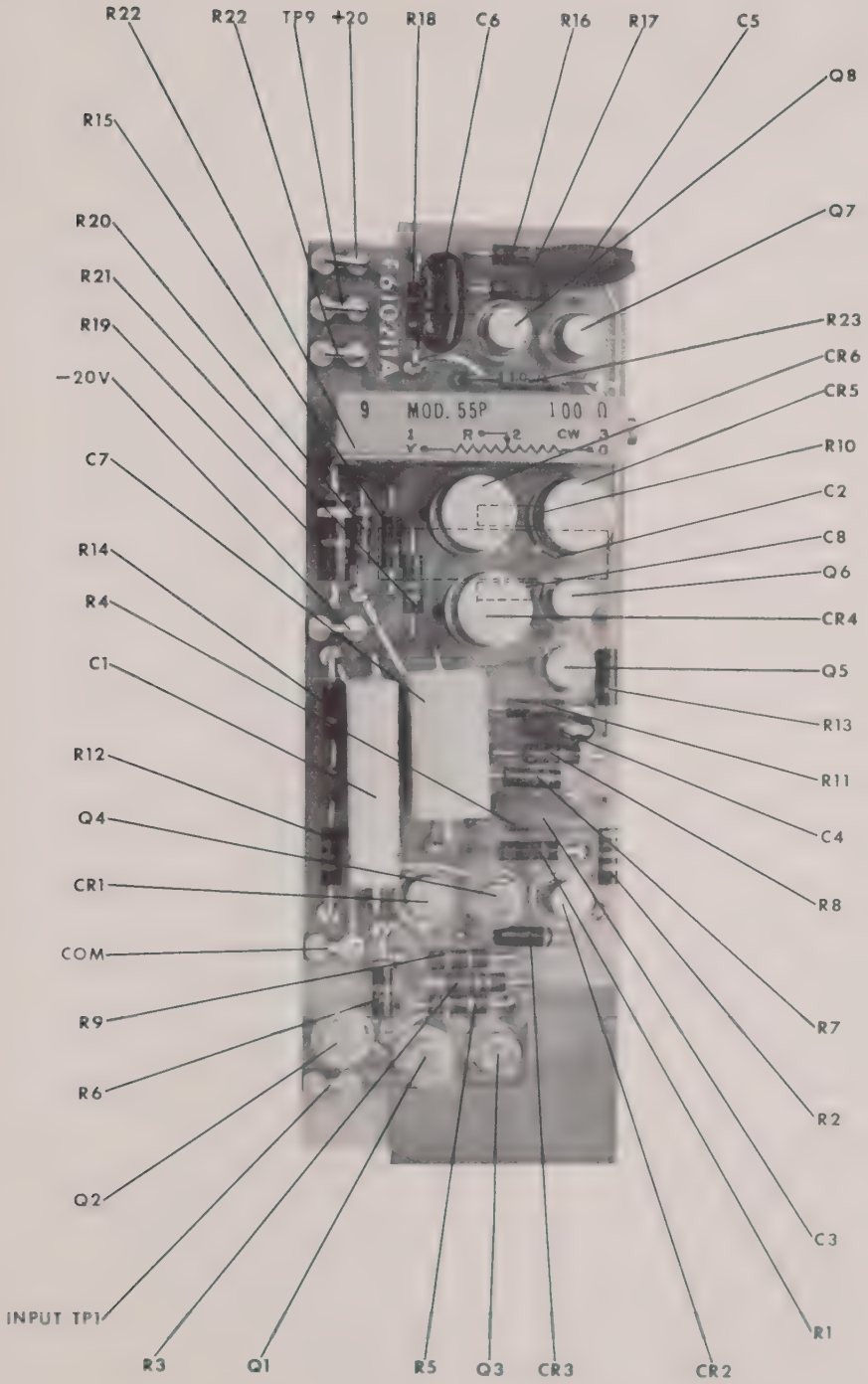


Figure 5-6. Attenuator Board A2 Parts Location

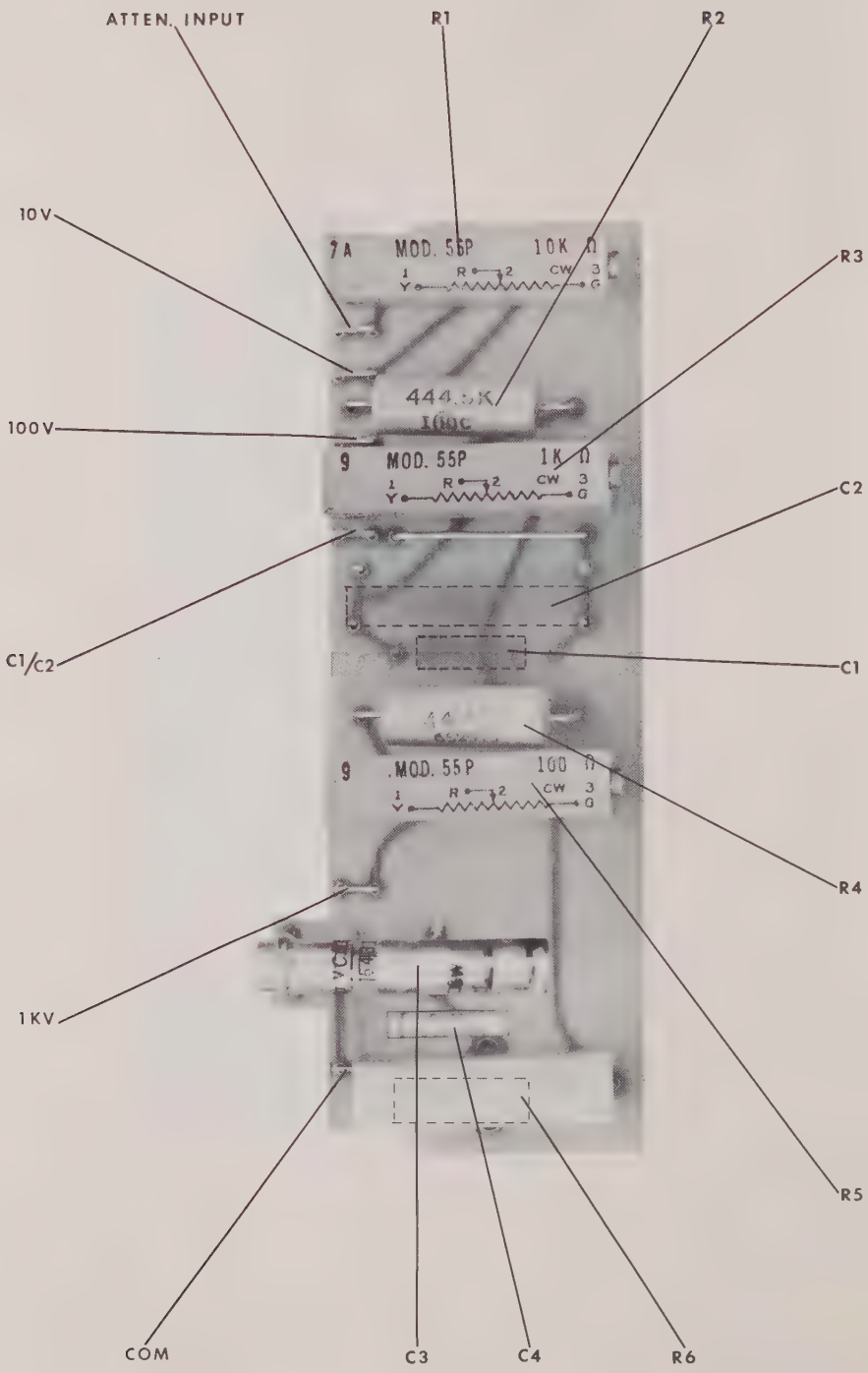
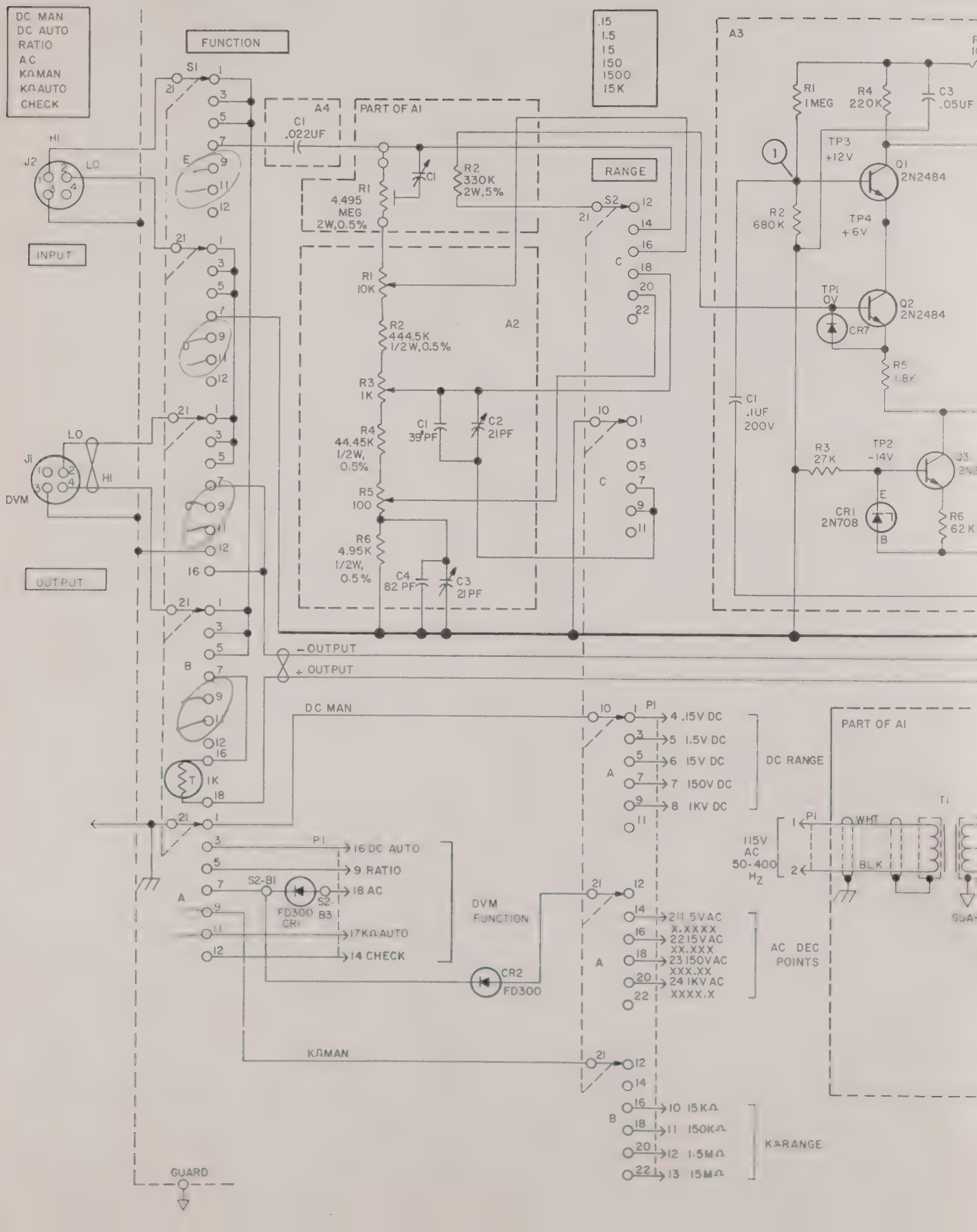
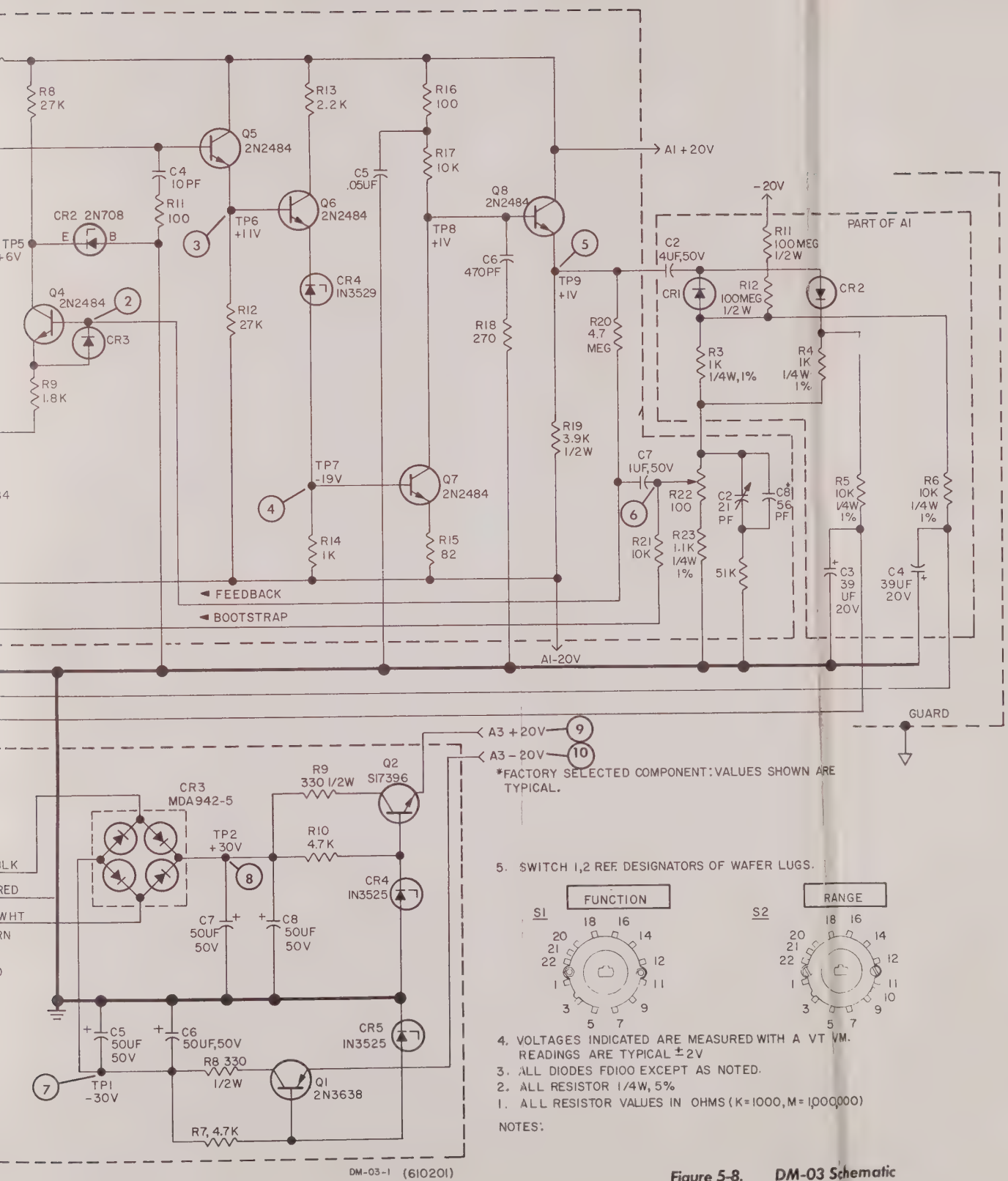


Figure 5-6 Board A2 Parts Location


DC MAN
DC AUTO
RATIO
AC
KΩMAN
KΩAUTO
CHECK
FUNCTION
S1
INPUT
J2
HI
LO
OUTPUT
J1
DVM
A4
C1 .022UF
PART OF A1
R1 4.495 MEG 2W,0.5%
C1
R2 330K 2W,5%
RANGE
S2
A2
R1 10K
R2 444.5K 1/2W,0.5%
R3 1K
R4 44.45K 1/2W, 0.5%
R5 100
R6 4.95K 1/2W, 0.5%
C1 39PF
C2 21PF
C4 82 PF
C3 21PF
.15
1.5
15
150
1500
15K
A3
R1 1MEG
R4 220K
C3 .05UF
TP3 +12V
Q1 2N2484
R2 680K
TP4 +6V
TP1 0V
Q2 2N2484
CR7
R5 1.8K
C1 .1UF 200V
R3 27K
TP2 -14V
CR1 2N708
R6 62K
-OUTPUT
+OUTPUT
DC MAN
P1
4 .15V DC
5 1.5V DC
6 15V DC
7 150V DC
8 1KV DC
DC RANGE
PART OF A1
T1
115V AC 50-400 Hz
WHT
BLK
GUARD
1K
16 DC AUTO
9 RATIO
18 AC
17KΩ AUTO
14 CHECK
S2-B1
S2-B3
FD300 CR1
DVM FUNCTION
CR2 FD300
KΩMAN
2 1.5VAC X.XXXX
22 15VAC XX.XXX
23 150VAC XXX.XX
24 1KV AC XXXX.X
AC DEC POINTS
10 15KΩ
11 150KΩ
12 1.5MΩ
13 15MΩ
KΩRANGE



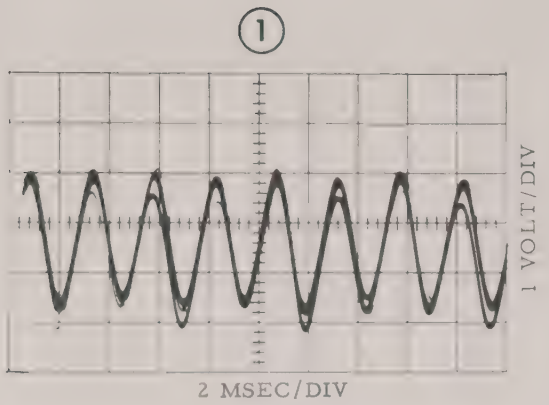
*FACTORY SELECTED COMPONENT: VALUES SHOWN ARE TYPICAL.

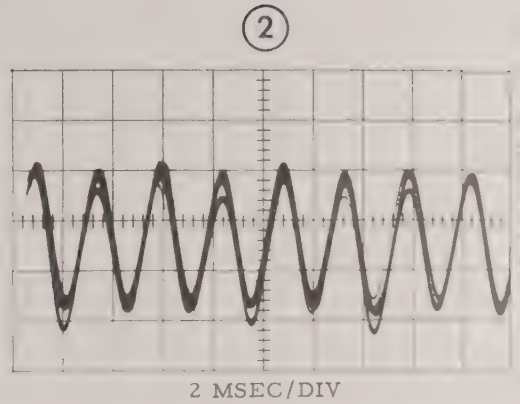
5. SWITCH 1,2 REF. DESIGNATORS OF WAFER LUGS.

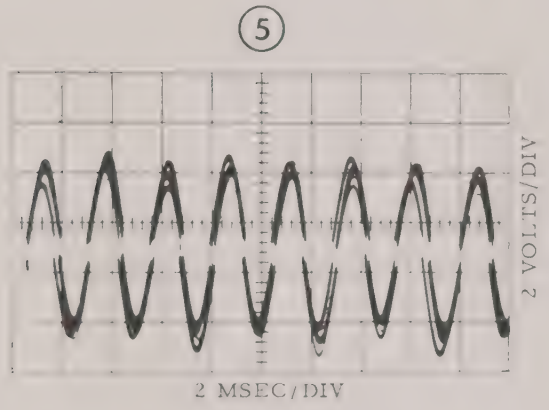
4. VOLTAGES INDICATED ARE MEASURED WITH A VT VM. READINGS ARE TYPICAL ± 2V
3. ALL DIODES FDI00 EXCEPT AS NOTED.
2. ALL RESISTOR 1/4W, 5%
1. ALL RESISTOR VALUES IN OHMS (K=1000, M=1,000000)

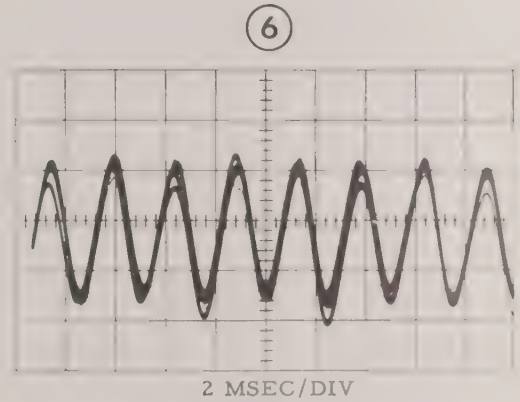
NOTES:

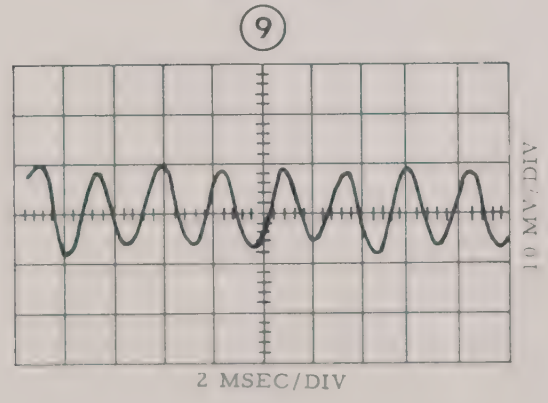
Figure 5-8. DM-03 Schematic

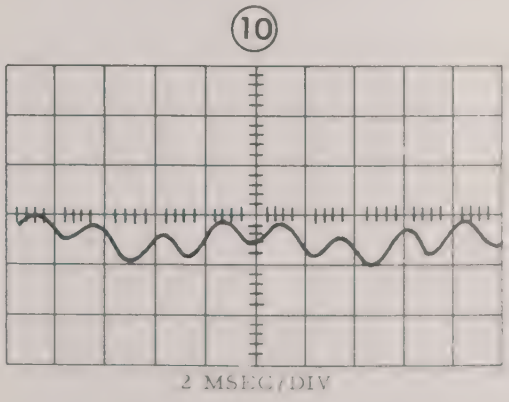

1
1 VOLT/DIV
2 MSEC/DIV

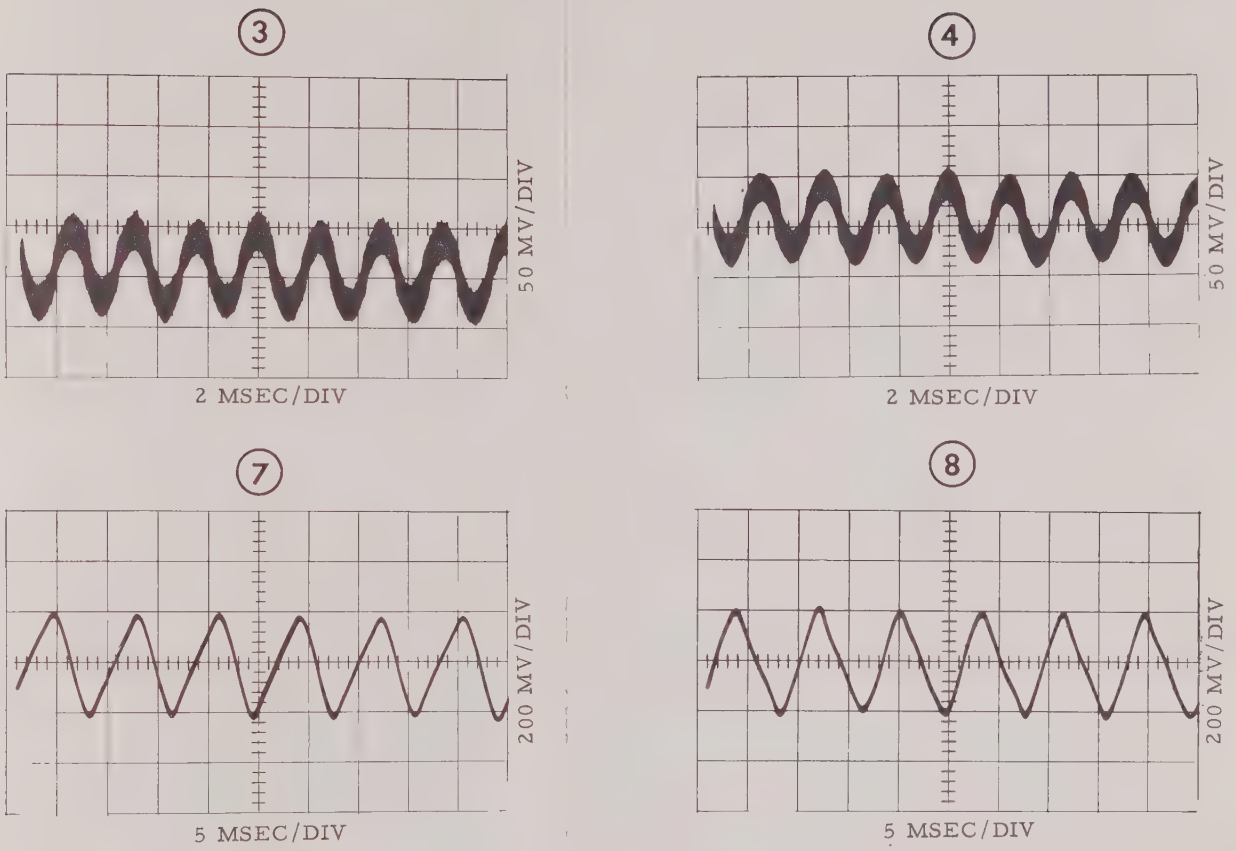

2
2 MSEC/DIV


5
2 VOLTS/DIV
2 MSEC/DIV


6
2 MSEC/DIV


9
10 MV/DIV
2 MSEC/DIV


10
2 MSEC/DIV



FUNCTION: AC

RANGE: 1.5 V

INPUT: 1 V, 400 Hz

OSCILLOSCOPE: Fairchild/Dumont 766H with Time Base plug-in 74-02A and Dual Trace plug-in 76-02A.

NOTE: In order to connect the oscilloscope to the test points, it is necessary to remove the instrument cover plates. This permits the introduction of HF noise into the circuitry with the result that some of the waveforms show evidence of this phenomenon.

Figure 5-9. Test Waveforms

SECTION VI
REPLACEMENT PARTS

6-1. GENERAL

6-2. Tables 6-1 through 6-4 contain information for ordering replacement parts, listing: circuit reference, description, manufacturer, and Fairchild Instrumentation part number. Table 6-5 lists recommended spare parts. This table constitutes the military recommended spare parts provisioning list for 1 to 3 years service in an isolated location.

6-3. ORDERING INFORMATION

6-4. To order a replacement part, address order to an authorized Fairchild Instrumentation sales representative or to: 844 Charleston Rd., Palo Alto, California 94303.

6-5. Specify the following for each part:

a. Model and serial number of instrument.

b. Fairchild Instrumentation part number.

c. Circuit reference designation, assembly number, or complete description.

6-6. To order a part not listed in table 6-1 through 6-5, provide a complete description of the part, including function and location.

ABBREVIATIONS

A-B	Allen Bradley Co.
Amphenol	Amphenol-Borg Electronics
AVCO	AVCO Electronics, Inc.
C-D	Cornell-Dubilier Electronics
Cont. Device	Continental Device Corp.
CTS	Chicago Telephone Supply
Electra	Electra Mfg. Co.
Electro-Cube	Electro-Cube Inc.
Elemenco	The Electro Motive Mfg. Co.
El Pac	Erie Technological Prod.
FI	Fairchild Instrumentation
FSC	Helipot Div., Beckman Inst. Inc.
Good-All	TRW Capacitor Div.
Helipot	Helipot Div., Beckman Inst. Inc.
Helitrim	Helipot Div., Beckman Inst. Inc.
Hopkins	Hopkins Engineering Co.
IRC	International Resistance Corp.
JFD	JFD Electronics Corp.
Motorola	Motorola Semiconductor Prod.
Raytheon	Raytheon Co., Components Div.
Sprague	Sprague Electric Co.
Switchcraft	Switchcraft, Inc.
VECO	Victory Engineering Co.

Table 6-1. Frame Assembly Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .022 μf, 1000 v	El Pac	5304-06
CR1	Diode, FD300	FSC	5152-08
CR2	Same as CR1		
J1	Connector, 4 pin	Switchcraft	6124-19
J2	Same as J1		
P1	Connector, 24 pin	Amphenol	6124-33
R1	Thermistor, 1 k	VELO	5290-99
S1	Switch, rotary	FI	B900039
S2	Switch, rotary	FI	B900040
	Knob, skirted bar	Raytheon	
	Cable, input and output	FI	6634-40

Table 6-2 Board A1 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, variable	FI	B610387, B610401
C2	Capacitor, fixed, 4 μf 50 v	Electro-Cube	5302-71
C3	Capacitor, fixed, 39 μf, 20 v	Sprague	5304-04
C4	Same as C3		
C5	Capacitor, fixed, 50 μf, 50 v	Sprague	5304-05
C6	Same as C5		
C7	Same as C5		
C8	Same as C5		
CR1	Diode, FD100	FSC	5151-37
CR2	Same as CR1		
CR3	Diode, MDA942-5	Motorola	5152-49
CR4	Diode, 1N3525	Cont. Devices	
CR5	Same as CR4		
Q1	Transistor, 2N3638	FSC	5154-82
Q2	Transistor, S17396	FSC	5154-87
R1	Resistor, fixed 4.495 M ±.5%, 2 w	IRC	5220-37
R2	Resistor, fixed, 330 k ±5%, 2 w	A-B	5240-63
R3	Resistor, fixed, 1 k ±1%, 1/4 w	Electra	5213-74
R4	Same as R3		
R5	Resistor, fixed, 10 k ±1%, 1/4 w	Electra	5213-89
R6	Same as R5		
R7	Resistor, fixed, 4.7 k ±5%, 1/4 w	A-B	5215-68
R8	Resistor, fixed, 330 Ω ±5%, 1/2 w	A-B	5215-39
R9	Same as R8		
R10	Same as R7		
R11	Resistor, fixed, 100 MΩ ±5%, 1/2 w	A-B	5216-31
R12	Same as R11		
T1	Transformer, power	FI	B900052

Table 6-3. Board A2 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 39 pf, 300 v		5304-02
C2	Capacitor, variable, 21 pf	JFD	5304-07
C3	Same as C2		
C4	Capacitor, fixed, 82 pf	ARCO	5304-03
R1	Resistor, variable, 10 k	Helitrim	5291-68
R2	Resistor, fixed, 444.5 k ±5%, 1/2 w	IRC	5220-36
R3	Resistor, variable, 1 k	Helitrim	5291-67
R4	Resistor, fixed, 44.45 k ±5%, 1/2 w	IRC	5220-35
R5	Resistor, variable, 100 Ω	Helitrim	5291-66
R6	Resistor, fixed, 4.95 k ±5%, 1/2 w	IRC	5220-34

Table 6-4. Board A3 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .1 μf, 50 v	Good-All	5302-16
C2	Capacitor, variable, 21 pf	JFD	5304-07
C3	Capacitor, fixed, .05 μf	Sprague	5301-24
C4	Capacitor, fixed, 10 pf	Elmenco	5300-45
C5	Same as C3		
C6	Capacitor, fixed, 470 pf	Elmenco	5300-84
C7	Capacitor, fixed, 1 μf	Electro-Cube	5302-10
C8	Capacitor, fixed, 56 pf		
CR1	Transistor, 2N708, selected for BV_{EBO} of 6 V ±0.5 V at 0.5 ma	FSC	FS S-17334
CR2	Same as CR1		
CR3	Diode, FD100	FSC	5151-37
CR4	Diode, 1N3592	Cont. Devices	5161-24
CR5	Not assigned		
CR6	Not assigned		
CR7	Same as CR3		
Q1	Transistor, 2N2484	FSC	5151-98
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
Q5	Same as Q1		
Q6	Same as Q1		
Q7	Same as Q1		
Q8	Same as Q1		
R1	Resistor, fixed, 1 M ±5%, 1/4 w	A-B	5231-31
R2	Resistor, fixed, 680 k ±5%, 1/4 w	A-B	5231-27
R3	Resistor, fixed, 27 k ±5%, 1/4 w	A-B	5230-93
R4	Resistor, fixed, 220 k ±5%, 1/4 w	A-B	5231-15
R5	Resistor, fixed, 1.8 k ±5%, 1/4 w	A-B	5230-65
R6	Resistor, fixed, 62 k ±5%, 1/4 w	A-B	5231-02
R7	Resistor, fixed, 100 ±5%, 1/4 w	A-B	5230-35
R8	Same as R3		
R9	Same as R5		

Table 6-4. Board A3 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R10	Resistor, fixed, 51 k ±5%, 1/4 w	A-B	5231-00
R11	Same as R7		
R12	Same as R3		
R13	Resistor, fixed, 2.2 k ±5%, 1/4 w	A-B	5230-67
R14	Resistor, fixed, 1 K ±5%, 1/4 w	A-B	5230-59
R15	Resistor, fixed, 82 Ω ±5%, 1/4 w	A-B	5230-33
R16	Same as R7		
R17	Resistor, fixed, 10 k ±5%, 1/4 w	A-B	5230-83
R18	Resistor, fixed, 270 Ω ±5%, 1/4 w	A-B	5230-45
R19	Resistor, fixed, 3.9 k ±5%, 1/2 w	A-B	5215-66
R20	Resistor, fixed, 4.7 M ±5%, 1/4 w	A-B	5231-47
R21	Same as R17		
R22	Resistor, variable, 100 Ω 1/5 w	Helipot	5291-66
R23	Resistor, fixed, 1.1 k ±1%, 1/4 w	Electra	5213-88

Table 6-5. Recommended Spare Parts and Circuit Board List

Description	FI Part No.	Total Used	Recommended Spares	Unit Price
	PARTS			
Diode, FD300	5152-08	5	2	
Diode, MDA942-5	5152-49	1	2	
Diode, 2N708, selected	5151-36	2	2	
Transistor, 2N2484	5151-98	8	2	10.00
Transistor, S17396	5154-87	1	2	
Transistor, 2N3638		1	2	
Transformer, Power	B900052	1	1	
Switch, rotary	B900039	1	1	
Switch, rotary	B900040	1	1	
	BOARDS			
Board, plug-in A2		1	1	
Board, plug-in A3		1	1	

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